
Factors influencing the removal of posts

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Abstract

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Aim To determine whether metal type, cement type and the use of ultrasonic vibration influence the amount of tensile force required to remove parallel-sided, prefabricated, metal posts from tooth roots.

Methodology Ninety extracted canine teeth were sectioned horizontally 1-mm coronal to the labial cemento–enamel junction and embedded in acrylic blocks. Standardized post spaces were prepared with a ParaPost no. 5 (1.25 mm) drill to 10 mm and ParaPost XP no. 5 stainless steel and titanium posts were cemented using zinc phosphate, glass ionomer or com-

posite resin cement. Sixty posts were subjected to 16 min of ultrasonic vibration whilst 30 stainless steel posts received no vibration. The force required for post removal was determined using a universal testing machine. Results were analysed using univariate ANOVA.

Results The univariate ANOVA revealed no statistically significant differences between the groups at the $P = 0.05$ level.

Conclusions In this *in vitro* experiment, metal type, cement type and ultrasonic vibration did not influence the force required to remove posts.

Keywords: biomaterials, root-canal posts, ultrasound.

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Introduction

Endodontic retreatment often involves the removal of intraradicular posts. In a study of 2000 patients treated in an endodontic practice, Abbott (1994) reported that 36.7% of the cases received endodontic retreatment and 25.7% of these initially required post removal. This represented 9.4% of all cases treated and demonstrates the need to be proficient at removing posts atraumatically to prevent cracks or vertical fractures developing in the roots.

Many techniques have been devised to aid the removal of posts. These include the use of burs or trephines, devices that grasp the posts so that they can be pulled out of the root and the use of ultrasonic vibration (Castrissos & Abbott 2002). Ultrasonic techniques involve the initial removal of restorative material and luting cement

from around the post, followed by application of the tip of an ultrasonic instrument to the post. Ultrasonic energy is transferred through the post and breaks down the cement until the post loosens. According to some authors, this method of post removal minimizes loss of tooth structure and decreases the risk of root damage (Krell *et al.* 1986, Chenail & Teplitsky 1987).

Factors that may affect the retention of a post are: (i) the post type (custom or prefabricated), (ii) the post design (parallel, tapered, smooth, serrated, threaded), (iii) the cementing medium, (iv) the cemented depth and (v) post adaptation in the root canal (Shillingburg & Kessler 1982, Sivers & Johnson 1992, Chan *et al.* 1993). Variation of any one of these factors may affect retention. Disruption of the luting cement securing the post is the most likely mechanism of action for ultrasonic vibration (Johnson *et al.* 1996). According to Buoncristiani *et al.* (1994), the viscoelastic nature of composite resin cements should dampen vibrations and absorb energy. Furthermore, conductance of vibratory forces within a post is proportional to the square root of the modulus of elasticity of the post material (Jaeger 1962). Titanium, which has a significantly lower modulus of elasticity

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(114 GPa) than stainless steel (193 GPa) (O'Brien 1989), should conduct vibrations less efficiently. Combining low-modulus post materials with resin cements may alter the effectiveness of ultrasound as an aid in post removal.

Several studies have investigated the effect of ultrasonic and sonic devices on the removal of posts (Krell *et al.* 1986, Buoncristiani *et al.* 1994, Berbert *et al.* 1995, Altshul *et al.* 1997, Bergeron *et al.* 2001, Gomes *et al.* 2001). The majority of these studies have tested the effect of ultrasonic vibration on cast posts or stainless steel parallel-sided posts with zinc phosphate cement, with the cemented depth varying between 4 and 9 mm. Two recent studies have tested the effect of ultrasonic vibration on the removal of cast posts and titanium posts cemented with different cements (Bergeron *et al.* 2001, Gomes *et al.* 2001). However, no study has investigated the effect of metal type on the removal of posts with the assistance of ultrasonics. The aim of this *in vitro* study was to determine whether the post metal, the cement type or ultrasonic vibration influenced the tensile force required to remove posts.

Materials and methods

Ninety extracted human canine teeth, free of defects and restorations in the roots and having narrow, unfilled root-canal spaces to accommodate standard-sized posts, were selected. The roots were sectioned horizontally, 1-mm coronal to the labial cemento–enamel junction. They were then grooved horizontally using a diamond bur and embedded in individual acrylic blocks moulded to fit a holding device. Standardized post spaces were prepared with ParaPost XP no. 5 (1.25 mm) drills (Coltene/Whaledent Inc., Mahwah, NJ, USA) to a depth of 10 mm. A new drill was used for every 10 teeth. The post spaces were irrigated with sodium hypochlorite and water and dried with paper points. The specimens were

randomly assigned to nine groups of 10 roots each. ParaPost XP no. 5 stainless steel posts were used in six groups with three different cements. Each cement was used for two groups. ParaPost XP no. 5 titanium posts were used in three groups with one of the cements for each group. The posts were checked for passive fit in the prepared canals. The cements used were: zinc phosphate cement (Zinc Cement Improved, SS White MFG Ltd, Gloucester, UK), glass-ionomer cement (Fuji I, GC Dental Industrial Corporation, Tokyo, Japan) and composite resin cement (Panavia F, Kuraray Co. Ltd, Osaka, Japan). The experimental groups are summarized in Table 1.

The preparation of dentine surfaces and the dispensing, mixing and handling of the cements were completed precisely as directed in the manufacturers' instructions. Posts were coated with the cement and seated to full depth using finger pressure. Excess cement was cleared from the root face and the posts were held in position until initial setting had occurred and then left undisturbed on the bench for a further 15 min. The specimens were stored in saline at 37 °C for 2 weeks.

Three groups with stainless steel posts and one of each of the three cements were not subjected to ultrasound. In the remaining groups, ultrasonic vibration was applied to the posts for 16 min at a level 2 mm above the coronal surface of the root. The ultrasonic unit EMS Piezon Master 400 (Electro Medical Systems, Nyon, Switzerland) was used with the power set to maximum and with water as coolant. The scaler tip (Type A) was continuously moved 360° around the post to induce resonance.

The specimens were placed in a holding device in a universal testing machine (Instron, High Wycombe, UK). The post end was grasped in a vice and a tensile force at a cross-head speed of 5 mm min⁻¹ was applied. A universal coupling in the testing machine ensured that the posts were loaded along their long axes. The force required to dislodge each post was recorded and the data

Table 1 Mean force required to remove posts

Cement	Post	Number	Mean force (N)	Standard deviation (N)
Zinc	SS (–)	10	224.69	99.26
Phosphate	SS (+)	10	210.81	88.84
(ZC)	Ti (+)	10	157.05	55.52
Glass	SS (–)	10	201.64	75.46
Ionomer	SS (+)	10	221.41	134.88
(FI)	Ti (+)	10	189.13	77.30
Composite	SS (–)	10	168.56	83.55
Resin	SS (+)	10	236.61	94.96
(PF)	Ti (+)	10	198.65	62.09

SS, stainless steel; T, titanium; +, ultrasound; –, no ultrasound; ZC, Zinc Cement Improved; FI, Fuji-Ionomer Type I; PF, Panavia F.

were analysed using SPSS statistical software (SPSS Inc., Chicago, IL, USA).

Results

The mean forces required to remove the posts and standard deviations are shown in Table 1. The SPSS General Linear Model – univariate ANOVA application provides analysis of variance for one dependent variable (force required to remove posts) by one or more factors (metal, cement, ultrasound). The analysis revealed no statistically significant differences between any of the groups at the $P = 0.05$ level.

Discussion

This study aimed to test the effects of the post metal, the cement and ultrasonic vibration on the forces required to remove posts from roots. The roots were not endodontically treated in order to eliminate a potential variable from the study, as the type of endodontic sealer may influence the retention of posts (Bergeron *et al.* 2001).

Etching, conditioning or chelating agents are sometimes used to treat the dentine of the post space in studies of this type. They were not used in the present study because the manufacturer of the zinc phosphate cement does not specify their use and the manufacturers of the glass ionomer and composite resin products specifically warn against removal of the smear layer.

Despite the large differences in mean values there were no statistically significant differences in the force required to remove stainless steel and titanium posts following the application of ultrasound. In addition, the type of cement did not affect the force required. Large standard deviations have clearly contributed to this result. The differences in the structure and composition of the dentine of the individual roots may also contribute to this variation as all of the other aspects of the study were strictly controlled. Clinicians face the same variability in teeth in their daily practice.

Bergeron *et al.* (2001) found that the type of cement was not a statistically significant factor for post retention. They reported a significant ($P = 0.01$) increase in the forces required to remove titanium posts following ultrasonic vibration, when zinc phosphate was compared with resin cements. They suggested that heat production might have been responsible for the increased retention following ultrasonic vibration, as they did not use water coolant. The authors further hypothesized that the low modulus of elasticity of the titanium may have been responsible for the ineffectiveness of ultra-

sound in reducing post retention. Similarly, in the present study, the type of cement was not a significant factor for post retention. After the application of ultrasound, the mean force required to remove stainless steel posts cemented with glass ionomer or composite resin increased, and the stainless steel posts, on average, required greater force to remove them than the titanium posts for all three cements. It could be speculated that cavitation of the water coolant at the tip of the instrument allowed the temperatures of the posts and cements to rise. It is also possible that the better conduction of the ultrasonic energy in stainless steel than in titanium caused a different heating effect between the groups. The extent of such temperature increases and their effects on cements should be investigated in future studies. In any event, the differences in the means were not statistically significant.

The 16 min of ultrasonic application chosen for this study was based on the results of the study by Johnson *et al.* (1996), who found that this period of time was needed to produce a significant reduction in the force required to remove parallel-sided posts cemented to a depth of 9 mm with zinc phosphate cement. Sixteen minutes of ultrasound application did not prove to be sufficient to reduce the tensile forces required to remove intraradicular posts in the current study or in the study of Bergeron *et al.* (2001). However, different ultrasonic devices were used in these studies. Buoncristiani *et al.* (1994) found significant variations amongst different ultrasonic devices in their ability to remove posts. The use of different machines may explain the inability to reproduce the results of Johnson *et al.* (1996) after 16 min of ultrasonic application. Sixteen minutes or more of clinically applied ultrasound may be impractical for some practitioners. However, in the clinical study by Smith (2001), the mean time required to dislodge posts with an ultrasonic instrument was approximately one-quarter of that reported for *in vitro* studies. Despite this, laboratory studies such as the current study, are useful in that they eliminate many of the variables present in clinical practice. The most likely explanation for posts being easier to remove in a clinical setting may be related to the reason for removing the posts in the first instance, namely infected root canals owing to coronal leakage. Leakage leads to breakdown of the cement retaining both the coronal restoration and the post. In clinical practice, posts should thus be easier to remove than those in laboratory studies where they were only cemented for a short time period (2 weeks in the current study), kept under optimal conditions and not in function. Other explanations for the clinical usefulness of ultrasonic

vibration in post removal may be suboptimal cementation techniques or early loading of posts in patients rather than an inherent susceptibility of posts or cements to ultrasonic vibration (Smith 2001).

Conclusions

1 Sixteen minutes of ultrasonic vibration did not significantly reduce the tensile forces required for post removal.

2 Post metal, cement type and use of ultrasonic vibration did not influence the force required to remove posts.

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